Early warning of tick-borne encephalitis: climatic variables and rodent density successfully explain *Ixodes ricinus* co-feeding transmission in northern Italy

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Tick-borne Encephalitis (TBE) is an important zoonosis in many parts of eastern and central Europe. The most efficient transmission route for the TBE virus (TBEv) seems to be the saliva-activated non-viraemic transmission between *Ixodes ricinus* ticks co-feeding on rodent hosts. During the period 2001-2014, a population of the yellow-necked mouse, (*Apodemus flavicollis*), was intensively live-trapped in a known TBE focus in the Province of Trento (northern Italy). The total numbers of feeding ticks at each life stage, as well as the number of co-feeding groups were recorded. In addition, a serological test for the detection of TBEv antibodies was carried out for each trapped rodent. First, a combined effect of climatic conditions and rodent density on the number of co-feeding groups was observed. Specifically, co-feeding occurrence on rodents during the season was affected by autumnal cooling of the previous season and was associated with rodent density in a humped (concave-down) relationship. Rodent weight and gender also affected co-feeding occurrence with the heaviest males carrying more co-feeding tick groups. In addition, we found that the overall number of co-feeding tick groups on rodents positively affected TBEv infection in rodents the following year. This is presumably due to a higher probability of feeding larvae to acquire TBEv infection during the season through co-feeding transmission; these larvae would moult and feed on rodents as infected nymphs the following season, thus increasing TBEv circulation and transmission risk. In conclusion, specific climatic conditions in conjunction with specific range of rodent densities are the principal drivers of co-feeding ticks on rodents and could be used to provide an early warning indicator for TBE risk. These simple predictors will potentially allow targeted public health actions to be implemented promptly, with implications for prevention and control of TBEv circulation.